Vision: Preventing Tech-related Physiological Health Issues using Commodity Wearables

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Abstract

The pervasive use of technology has led to a rise in tech-related health issues such as tech neck, eye strain, carpel tunnel syndrome, and hearing loss. These issues stem from prolonged and improper device usage, leading to long-term physiological strain. We envision TechWell, a wearable-driven ergonomic assistant designed to proactively mitigate these health issues through real-time multimodal sensing and AI-driven interventions. By leveraging commodity wearables such as smart glasses, smartwatches, and earables, TechWell integrates context-aware sensing, machine learning, and personalized feedback mechanisms to provide an adaptive approach to digital ergonomics. This paper outlines our vision for TechWell, exploring key research directions and technical challenges in realizing this vision. We aim to embed ergonomic intelligence into everyday technology use.

Keywords

Wearable Health Sensing, Multimodal Sensing, Tech Neck

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1 Introduction

The integration of smartphones, laptops, and other digital devices into daily life has fundamentally changed the way humans interact with technology. While these devices have brought unparalleled convenience and efficiency, they have also led to an unprecedented rise in physiological health problems associated with prolonged usage. Neck pain, commonly referred to as tech neck, affects approximately 45% of office workers annually, driven by prolonged forward head posture [11]. Digital eye strain (DES) is similarly widespread; a study of over 10,000 U.S. adults reported 65% experiencing symptoms [10]. Carpal tunnel syndrome, tied to repetitive wrist activity, impacts an estimated 5% of the population, particularly among desk-based professionals [11]. Hearing loss is also on the rise, with 33% of personal listening device users showing signs [6]. These problems, once considered isolated cases, have now become widespread public health concerns in the digital age.

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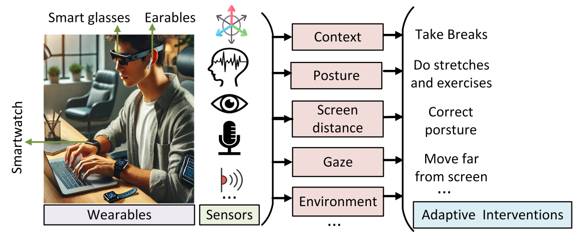

Figure 1: TechWell vision

Current interventions for these conditions are largely reactive, relying on users to self-monitor their posture or take breaks. However, such approaches often fail due to lack of awareness, compliance fatigue, or the absence of real-time feedback. The proliferation of wearables, including smartwatches, smart glasses, and earbuds, presents an opportunity to shift from reactive to proactive ergonomic health solutions. We propose TechWell, a multi-modal, AI-powered system that harnesses commodity wearables to continuously monitor posture, screen habits, wrist positioning, and auditory exposure, delivering personalized interventions to prevent health deterioration before it occurs. By embedding real-time sensing and adaptive feedback mechanisms directly into users' existing digital environments, TechWell has the potential to transform the way we interact with technology, ensuring that health and productivity are no longer at odds. We discuss the potential research directions and key challenges in realizing this vision.

2 Potential Research Directions

Since wearables are ubiquitous, we propose using commodity wearable devices to prevent key health problems associated with the prolonged or improper use of devices.

Head-worn wearables for tech neck: Tech neck, caused by prolonged forward head posture while using digital devices, can lead to a range of musculoskeletal and physiological issues. It is a particularly serious issue in children and adolescents, as their bones, muscles, and nervous systems are still developing. As head-worn wearables become increasingly sophisticated, it provides an opportunity to continuously monitor head, neck, and spinal posture. Existing approaches primarily rely on placing inertial measurement units (IMUs) at the back of neck [2, 8] to detect excessive forward flexion, but these require sticking a device on the back and often suffer from drift and calibration issues. Emerging sensing techniques, such as electromyography (EMG) and electroencephalography (EEG), electrooculography (EOG), are being integrated into head-worn wearables, which could provide deeper insights into muscle strain, allowing for more precise interventions [1, 3, 5].

Smart glasses for DES: Prolonged exposure to the screen leads to DES, causing dry eyes, headaches, and blurred vision, with increased risks of myopia and cognitive fatigue. Current solutions, such as blue light filters and scheduled breaks, offer only reactive relief. Apple's screen distance feature warns users about close viewing, but it lacks real-time adjustments based on strain indicators. Moreover, it uses a camera that is computationally expensive and raises privacy concerns. We propose using smart glasses with gaze tracking, infrared sensors, and adaptation of ambient light for personalized interventions in real time. By monitoring screen distance, blink rate, and pupil dilation, the system can dynamically adjust brightness, contrast, and font size while issuing automated blink reminders. Unlike static solutions, this adaptive approach optimizes screen ergonomics, preventing strain before it escalates [7].

Smartwatch for Carpel Tunnel Syndrome: While smartwatches are widely used for various applications, their potential for preventing strain remains underutilized. Existing approaches have explored smart wristbands with flex sensors to detect wrist posture [9]. We can use smartwatch-based sensing system that continuously analyzes typing behavior, wrist positioning, and grip force. By detecting poor wrist posture and excessive pressure on the median nerve, the system can provide haptic feedback or guided exercises to prevent strain.

Earables for hearable loss prevention: Prolonged exposure to high-volume audio and noisy environments contributes to noise-induced hearing loss and auditory fatigue. Current solutions, such as Apple's Hearing Health system, provide notifications when volume exceeds safe limits, but it lacks personalized adjustments based on user behavior. We propose earable-based system that automatically adjusts headphone volume in real-time based on ambient noise levels, personal listening patterns, and cumulative sound exposure. By integrating EEG or inner-ear biosensors, the system can detect early signs of auditory fatigue [4] and provide proactive interventions, such as adaptive sound filtering, haptic alerts, or personalized listening recommendations, to prevent long-term hearing damage.

3 Research Challenges

While TechWell presents a promising vision for wearable-driven ergonomic health, several technical and human-centered challenges must be addressed.

Differences in user anatomy: Variability in user anatomy presents a key challenge, as individuals have different head tilt baselines, natural postures, muscle strength, and health issues. For example, some people could have weaker back muscles or vision problems, so they need to be alerted more frequently than others. Developing personalized AI models that adapt to individual physiological baselines will be essential for ensuring accurate recommendations.

Context Dependency: Context awareness is another major limitation. Posture correction reminders, brightness adjustments, or volume alerts must be contextually appropriate. For instance, a posture correction prompt that is relevant while sitting at a desk may be completely unnecessary when walking. So, it is important to sense the context to tailor feedback based on real-time user activity.

Sensor Limitations: As discussed earlier, prolonged device usage leads to neck pain, upper back pain, shoulder pain etc. But commodity wearables are not present at these locations, so we need to estimate the movement of these muscles using commodity wearables data. Also, many consumer-grade wearables lack dedicated sensors for muscle strain or deep physiological monitoring, requiring the use of inference models based on existing wearable data. Additionally, IMU-based posture tracking suffers from drift errors, making multi-sensor fusion techniques crucial for maintaining accuracy over time.

Privacy: Privacy concerns arise when dealing with biometric and behavioral monitoring. Ensuring data security, local processing, and user transparency is crucial to promoting adoption.

Seamless Integration: Users are unlikely to adopt a system that requires frequent manual input, generates excessive notifications, or disrupts their workflow. The interventions must be passive, adaptive, and low-friction, ensuring that users receive benefits without feeling overwhelmed by technology.

Power Efficiency: Wearables continuously collecting and processing multimodal data require significant power, which can drain batteries quickly. Frequent charging reduces usability and adoption. Low-power AI models, on-device processing, and energy-efficient sensors are needed to make real-time sensing feasible for daily use.

4 Conclusions

Technology is deeply embedded in daily life, and people are not going to stop using digital devices despite their adverse physiological effects. Instead of expecting behavioral changes, we must focus on seamlessly mitigating the negative health impacts of technology through adaptive, seamless wearable-driven interventions. TechWell represents a step toward this vision by integrating real-time multimodal sensing and AI-driven feedback into everyday devices. However, several challenges remain, including sensor limitations, personalization, privacy, and usability. Future research must focus on making these interventions more accurate, context-aware, and unobtrusive, ensuring that productivity and well-being are no longer in conflict, but instead, mutually reinforced.

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